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NAVORD REPORT 2494

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A SMALL SCALE GAP SENSITIVITY TEST

2 July 1952

U. S. NAVAL ORDNANCE LABORATORY

WHITE OAK, MARYLAND

SECURITY INFORMATION

A SMALL SCALE GAP SENSITIVITY TEST

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ABSTRACT: This report describes a method whereby the sensitivity of explosives to initiation by other explosives may be evaluated when only a small sample of the explosive is available. Cylindrical brass containers 1" in diameter and 1/4" long with 0.100" diameter centrally drilled holes were used to contain the explosive to be tested. The use of such small columns makes it possible to obtain statistically valuable data from small amounts of explosive. The depth of a dent in a steel block placed at the back of the explosive column was used as a criterion to determine whether the shot was a fire or misfire. The order of decreasing sensitivity of the five explosives tested was found to be RDX, tetryl, Comp B, TNT and Comp A. This is in agreement with results of similar larger scale experiments.

Explosives Research Department
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WHITE OAK, MARYLAND

The objective of the investigation reported is a part of the broader objective of devising valid small scale tests of explosives, especially when only limited quantities of experimental explosives are available. This work was authorized by Task Assignment NOL-Re2c-1-1(EP) and NOL-Re2b-41-1-52. The technique may be used for determination of sensitivities of explosives to initiation. The conclusions presented herein are preliminary and subject to modification after further study. However, the consistency of the data inspires confidence in the accuracy of the conclusions. The data and interpretation presented herein are for information only and not intended as a basis for action.

E. L. WOODYARD
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Commander

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J. E. ABLARD
By direction

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Introduction

The sensitivity of explosives is a complex subject. The relative sensitivity of two explosive compounds as measured by one means may be reversed when measured by another. This can be true even when both experiments seem fundamentally the same, as for example impact sensitivities as measured in two machines, or ignition points measured by two techniques. Thus in evaluating the sensitivity of a new compound, several types of measurement are desirable.

One type of sensitivity which is of particular interest is the sensitivity of an explosive to initiation by the action of another explosive charge. A number of experimental methods have been devised to measure this property of an explosive, including minimum priming charge experiments and various booster sensitivity tests.

Minimum priming charge experiments have several difficulties including the following:

(1) The minimum priming charge may be so small that the detonation thereof cannot build up to a stable process. The results thus become a function of the rate of growth of detonation in the priming charge explosive, a property which may vary considerably for the same compound, e.g., with states of aggregation.

(2) Such experiments necessarily involve either, (a) the loading of a quantity of samples with priming charges so far from the critical value as to be of little use in determining the critical value, or (b) loading samples with adjusted priming charges determined by results obtained with previous experiments. The first alternative is wasteful of effort, and the second involves the inconvenience of synchronizing loading and firing operations.

In an attempt to eliminate some of these difficulties a minimum booster test was devised at the Explosives Research Laboratory of the National Defense Research Council, Bruceton, Pennsylvania, reference (a). In this test various sizes of boosters were combined with various thicknesses of wax barriers to obtain a series of boosters of graduated output. By this means a large number of explosives which were under investigation at that time (1945) were classified as to booster sensitivity.

While the above tests were in progress, the "Bruceton up and down" test was devised, reference (b), for use with impact sensitivity. After the war, some of the scientists who had been members of the Explosives Research Laboratory staff joined the Naval Ordnance Laboratory staff. Here they combined the booster sensitivity test with the "Bruceton up and down" method to evolve a new booster sensitivity test, reference (c), in which the sensitivity could be characterized by the thickness of a wax barrier through which detonation could be transmitted 50% of the time. This wax barrier was placed between a standard booster and the explosive in question.

Although both of the above experiments yielded valuable data, the quantity of explosive required is prohibitive for materials which are in the laboratory stage of development. The work reported in reference (d) encouraged the belief that a test might be designed whereby this type of sensitivity may be determined when only small samples of explosive are available. The present report is an account of some preliminary studies directed toward the development of such a test.

Experimental Procedure

The experimental arrangement used in this work consisted of two columns of explosive, one of which is called the donor and the other the acceptor, separated by varying thicknesses of aluminum, Figure 1. The columns were encased in thick walled tubes of several different materials. The thickness of aluminum barriers through which detonation could be transmitted from donor to acceptor was used as a criterion of sensitivity. The aluminum barriers were used instead of air gaps because when using aluminum the gap varies proportionally, much less with acceptor loading density than when using air, reference (e). This would reduce the effect of any error that might be involved in the loading process. In all cases the compounds in the acceptors were loaded to 87% ± 1% of crystal density. The donors were of the same type used in reference (d). All acceptors were cylindrical pieces 1" in outside diameter by 0.1 inside diameter.

In the work discussed in reference (d) acceptors with 1" long columns were used. A substantial reduction in this length would result in a corresponding saving of explosive. An effort was thus made to determine the minimum length required for significant results.

At first 1/8" long steel acceptors were loaded with RDX and TNT. At this stage it was thought that the depth of dent obtained in a plain cold-rolled steel block placed back of the acceptor, Figure 1, would provide a good criterion for determining whether the shot was a fire or misfire. But in preliminary trials with TNT no definite break was obtained in the relation between gap and depth of dent; in fact the plot of the relation between gap and dent depth was almost a smooth curve. It was then decided that a longer column of explosive would be necessary and 1/4" long brass acceptors were subsequently employed. These acceptors gave a very sharp break in the curve for RDX and a seemingly sufficient break with TNT. Following this, 1/4" long steel and 1/2" long brass acceptors were used, but they were not significantly better than the 1/4" long brass.

Because the dents produced were almost invariably either considerably deeper or considerably shallower than 0.005 it was decided that a dent deeper than 0.005 would be considered evidence of a fire and a dent less than 0.005 a misfire.* Five different explosives were then loaded into the 1/4" brass acceptors (20 acceptors per explosive) and a standard Bruceton test employed with each explosive.

In conjunction with the above work, 1" long aluminum acceptors (with 0.100 column) were loaded with the same five explosives as used with the 1/4" brass and a Bruceton test applied (20 shots per explosive). The experimental arrangement here was the same as was described in reference (d).

Results

Figure 1 shows the experimental arrangement using the 1/4" brass acceptors. Table 1 gives the 50% points for the five explosives using both the 1/4" brass and 1" aluminum acceptors. It also shows comparative sensitivities for the same explosives as determined by other methods.

Conclusions and Discussions

The data in Table 1 prove aluminum acceptors to be less efficient than brass as confining media. It will be observed that the 50% point for TNT in the aluminum acceptors is given as < 0.010. This might indicate that with the aluminum confinement of the acceptor column the 0.100 diameter cavity is approaching the critical diameter for detonation of TNT. The acceptor did fire when zero gap was used, but it was a low order detonation.

In support of this, velocities of the order of only 1,900 meters per second were obtained, reference (e), with TNT in aluminum

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*The choice of 0.005 as the critical depth was influenced by the consideration that the test was for the purpose of establishing the relative safety of various explosives. A larger dent might be specified in a reliability test.

acceptors with 0.100 diameter columns. This is to be compared with a velocity of over 5,500 meters per second for the TNT loaded at the same density in steel and copper.

The relative order of sensitivity of the five explosives is not the same using the 1/4" brass acceptors as when using the 1" aluminum acceptors. Statistical analysis indicates that this reversal is significant although the relatively small number of shots involved reduces confidence in the results. Comp B and TNT are the least sensitive in both cases (although their order is reversed), and tetryl and RDX are the most sensitive (their order being reversed also). The effect of confining media upon the sensitivity of various explosives might be expected to vary.

The techniques described herein provde a promising means of evaluating the sensitivity of explosives to initiation by means of nearby detonation. Examination of Table 1 shows that the results obtained with the 1/4" brass acceptors agree with other measurements of this property as well as they agree among themselves. The results with aluminum are an interesting demonstration of the fact that it is not possible to measure sensitivity of an explosive, but only of a system of which the explosive is a part.

W. E. Dimmock, Jr.

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Table 1

Sensitivities of Selected Explosives by Various Methods

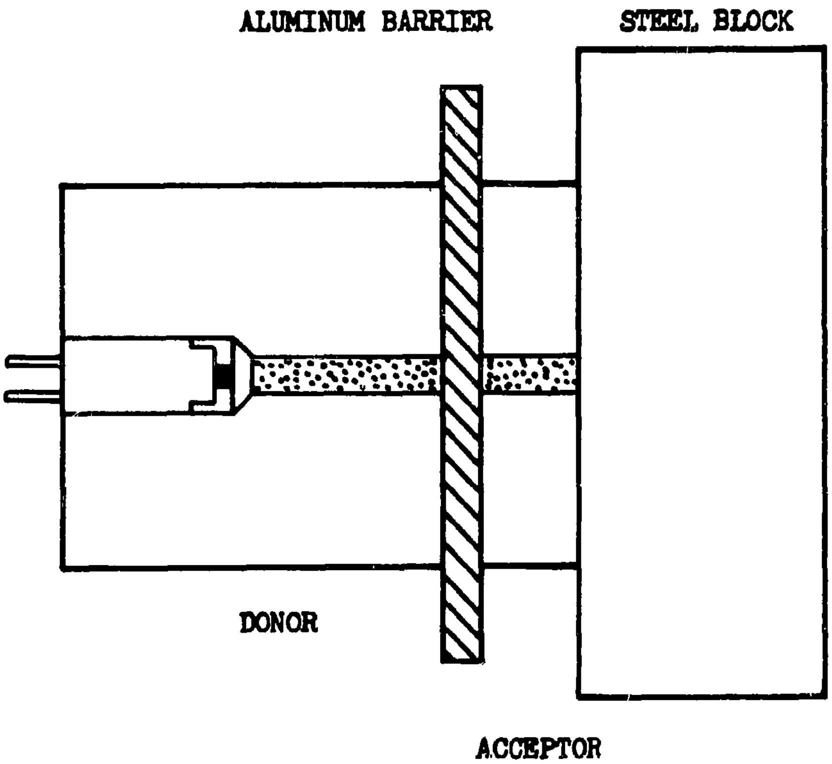
	Result of Present Work: 1/4" Brass Acceptor	Result of Present Work: 1" Al Acceptor	Booster Sensitivity Test(c)	Booster Sensitivity Test*(a)	Air Gap**(d)	Minimum Priming Charge of DDNP (gm)(d)	Drop Test Height (cm)(f)
Comp A	0.046"	0.017"	1.70"	10	0.065"		63
TNT	0.049"	< 0.010"	1.68" (0.82")	9	0.075"	0.29	161
Comp B	0.062"	0.0385"	(1.40")	6	0.11"	0.21	46
Tetryl	0.082"	0.061"	2.01"	4	0.15"	0.17	39.5
RDX	0.101"	0.050"	2.33"	2	0.33"	0.13	28.5

* Indicates relative inverse order of sensitivity.

** Between rigidly confined columns 0.150" in diameter of lead azide and the explosive mentioned. Donors confined in brass, acceptors in copper.

Numbers in parentheses refer to cast explosives.

(c), (a), (d), (d) and (f), see corresponding lettered references.



Experimental Arrangement for Small Scale Test

FIG. 1

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(b) OSRD No. 4040, Statistical Analysis for a New Procedure in Sensitivity Experiments (Statistical Research Group, Princeton University)

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(f) NavOrd Report 1589, Impact Sensitivity Determinations of Explosive Compounds Tested During the Period from 1 January 1950 to 1 November 1950, N. D. Mason

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